

## Kinetics of Hot-Gas Desulfurization Sorbents for Transport Reactors

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### ABSTRACT

The reactivity of AHI-5 sorbent was examined. This sorbent, consisting of 75 w%  $\text{Fe}_2\text{O}_3$ , 15 w%  $\text{ZnO}$ , and 10 w% inerts, was obtained from the Research Triangle Institute (RTI). The objectives of this project are to study initial reaction kinetics for the AHI-5 sorbent-hydrogen sulfide heterogeneous reaction system, to investigate effects of concentrations of hydrogen sulfide, hydrogen, and moisture on initial dynamic absorption of  $\text{H}_2\text{S}$  into the sorbent, and to evaluate effects of temperature and amounts of the sorbent on initial dynamic absorption of  $\text{H}_2\text{S}$  into the sorbent.

Experimental data on initial reaction kinetics of hydrogen sulfide with the sorbent were obtained with a  $0.83\text{-cm}^3$  differential reactor. The sorbent in the form of  $70\text{-}\mu\text{m}$  particles are reacted with 9000 – 18000 ppm hydrogen sulfide at  $350\text{--}500^\circ\text{C}$ . The range of space-time of reaction gas mixtures is  $0.071\text{--}0.088$  s. The range of reaction duration is  $4\text{--}10800$  s. The pressure of the reactor is maintained at 40.7 psia. Most reaction of  $\text{H}_2\text{S}$  with the sorbent appears to occur for the first 180-second reaction duration. The controlling steps for the initial absorption of  $\text{H}_2\text{S}$  into sorbent particles are surface reaction of  $\text{H}_2\text{S}$  with reactive sites of sorbent particles and intraparticle diffusivity of  $\text{H}_2\text{S}$  through pores of the sorbent. A reaction equation was applied to experimental data to obtain both intraparticle diffusivity values of  $\text{H}_2\text{S}$  and reaction rate constants of  $\text{H}_2\text{S}$  with the AHI-5 sorbent

Initial absorption of  $\text{H}_2\text{S}$  into the AHI-5 sorbent is affected with absorption temperature for short absorption duration of 4 - 180 seconds. The range of surface reaction rate constants is  $0.16\text{--}1.2\text{ cm/s}$ . The range of intraparticle diffusivity values of the sorbent is  $0.0002\text{--}0.0029\text{ cm}^2/\text{s}$ . Surface reaction rate constants, obtained from the reaction equation, are applied to the Arrhenius equation. Surface reaction rate constants appear to agree fairly with the equation in the temperature range of  $350\text{--}475^\circ\text{C}$ .

Experiments on effects of sorbent amounts on initial dynamic absorption of  $\text{H}_2\text{S}$  into the sorbent were conducted for the reaction duration of 4 – 180 seconds at  $450^\circ\text{C}$  and the space-time of 0.076 s. Amounts of the AHI-5 sorbent affect slightly initial dynamic absorption of  $\text{H}_2\text{S}$  into the sorbent in the sorbent amount range of 0.005– 0.02 g. The range of surface reaction rate constants is  $0.86\text{--}1.11\text{ cm/s}$ , and the range of intraparticle diffusivity values is  $0.0018\text{--}0.0025\text{ cm}^2/\text{s}$ . The concentrations of both hydrogen and moisture were maintained at 10-volume percent. The concentration of  $\text{H}_2\text{S}$  was maintained at 18000 ppm. Absorption of  $\text{H}_2\text{S}$  into the sorbent increases with decreased amounts of the sorbent in the reactor.

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### **Publications and Presentations**

-“Reactivity of Sorbents with Hot Hydrogen Sulfide in the Presence of Moisture and Hydrogen”, accepted for publication in Separation Science and Technology.

- “Reactivity of Metal Oxide Sorbents in the Removal of Hot Hydrogen Sulfide”, published in Recent Developments in Air Pollution Control, Page 77 – 87, edited by Mark P. Cal, Topical Conference Proceedings for Spring AIChE National Meeting, March 5-9, 2000, Atlanta, GA.

- “Reactivity of Sorbents with Hot Hydrogen Sulfide in the Presence of Moisture and Hydrogen”, presented at the Eleventh Symposium on Separation Science and Technology for Energy Applications, Park Vista Hotel & Convention Center, Gatlinburg, Tennessee, October 17-21, 1999.

- “Reactivity of Metal Oxide Sorbents in the Removal of Hot Hydrogen Sulfide”, presented at the Spring AIChE National Meeting, March 5-9, 2000, Atlanta, GA.

-“Initial Reactivity of Metal Oxide Sorbents with H<sub>2</sub>S at High Temperatures”, presented at the DOE Annual Contractors’ Review Meeting, National Energy Technology Laboratory, Pittsburgh, Pennsylvania, June 8 – 9, 2000.

-“Initial Reactivity of AHI-5 Sorbent with H<sub>2</sub>S at High Temperatures”, submitted for publication in Advances in Environmental Research.

### **Students Receiving Support from the Grant**

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